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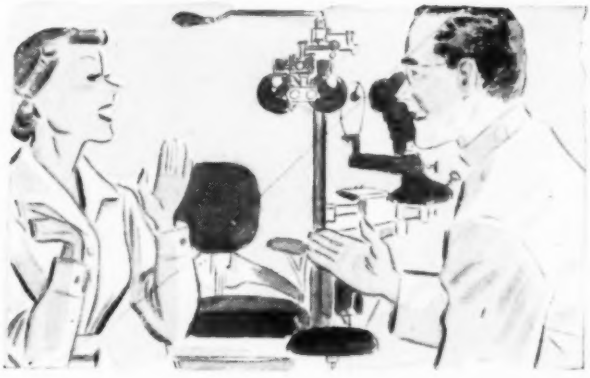

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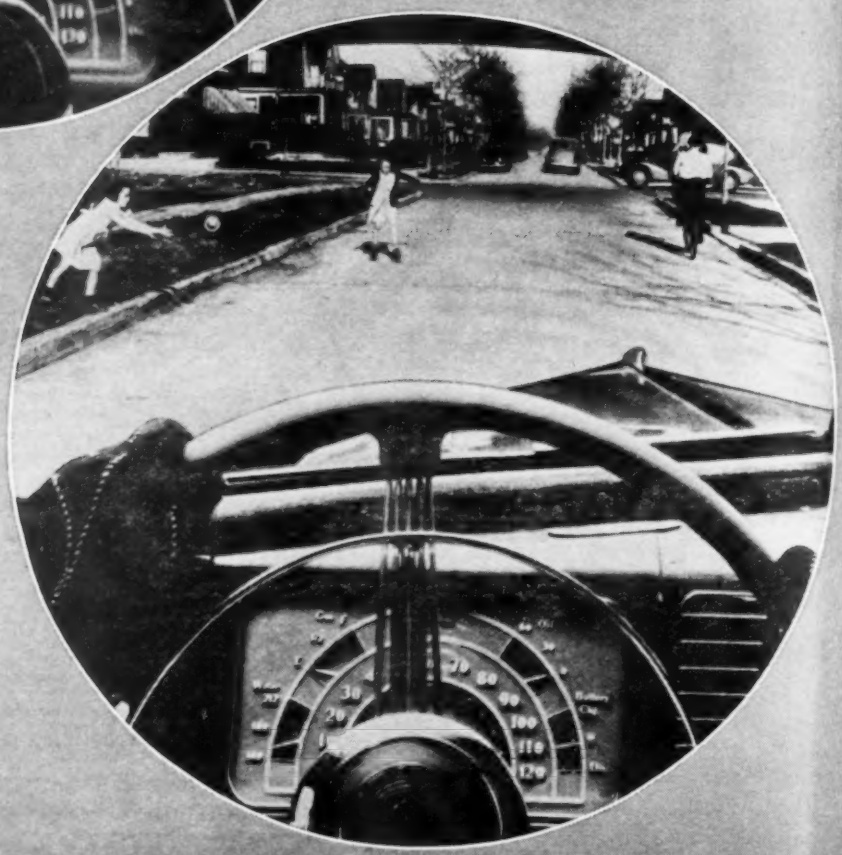

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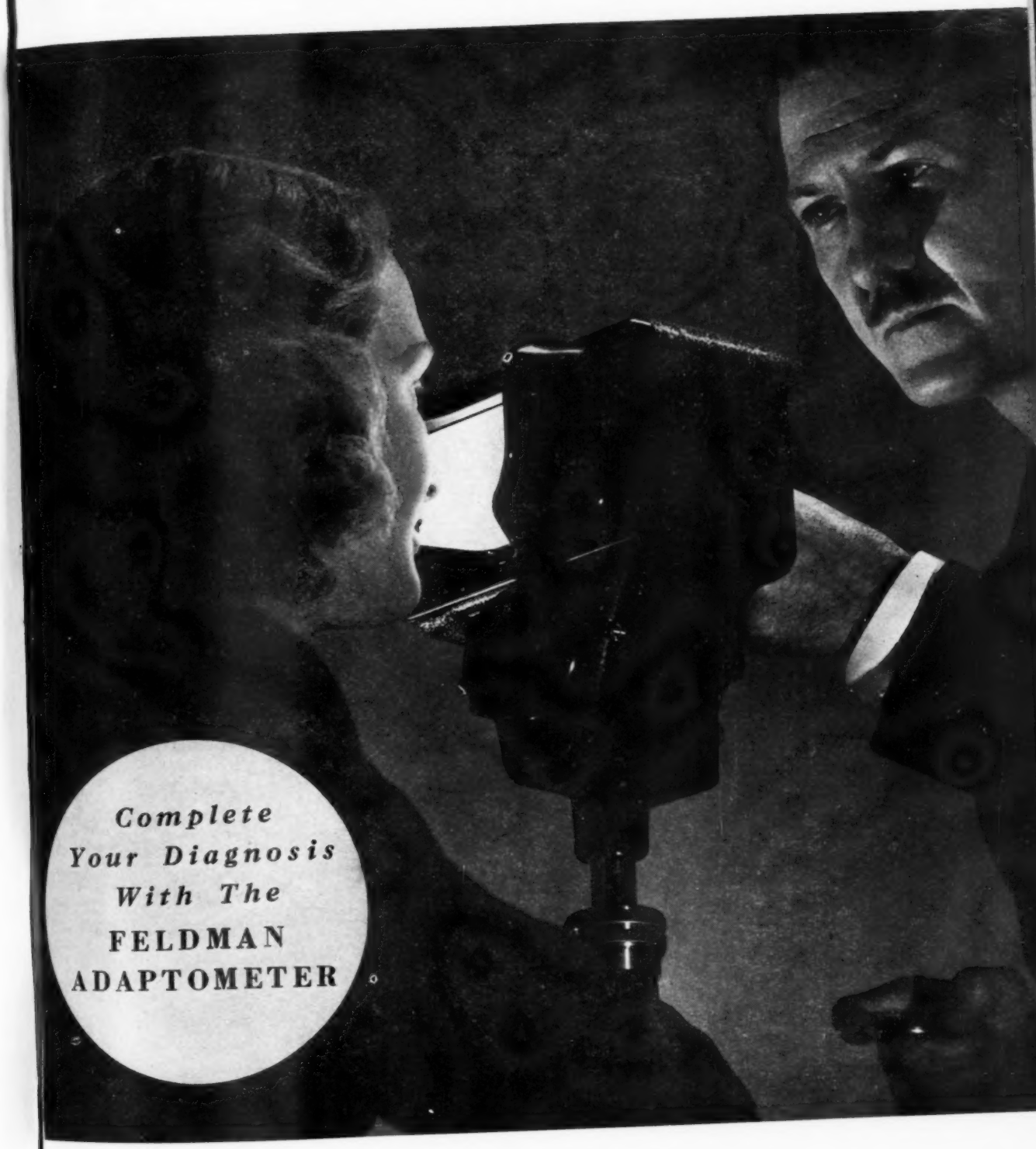

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AMERICAN JOURNAL OF OPTOMETRY

Vol. 16 MAY, 1939 No. 5

"NEW DEVELOPMENTS IN ANISEIKONIA"*

Julius Neumueller, O.D., F.A.A.O.
Southbridge, Mass.

This resume of aniseikonia is prompted by some of the work done during the last two years by the Department of Research in Physiological Optics at Dartmouth Medical School, Hanover, N. H. The results of this research tend to confirm again the correctness of the clinical test and to establish new concepts, the far-reaching influences of which cannot at present be appraised.

In order to have a common point of departure it may be advisable to restate the definition of, the tests for, and the functional disturbances connected with aniseikonia.

"Aniseikonia" means incongruity in the relative size and shape of the ocular images. The ocular image is the visual impression produced in the brain by one of the eyes. Its form is determined both by the characteristics of the dioptric image formed on the retina and the characteristic disposition of nerve points in the retinal structure. Further reference to "image size" should be understood to mean the size of the ocular image and not that of the dioptric image formed on the retina.[1]

There are three main types of aniseikonia:

1. Overall size difference.
2. Meridional size difference.
3. Compound difference or combination of meridional and overall size difference.

The test for aniseikonia is performed by means of the ophthalmo-

1. Clinical Treatment of Aniseikonia, Leo F. Madigan and Elmer H. Carleton, M.D., 1934.

*An abridgment of the material presented before the American Academy of Optometry at Richmond, Va., June 22, 1938.

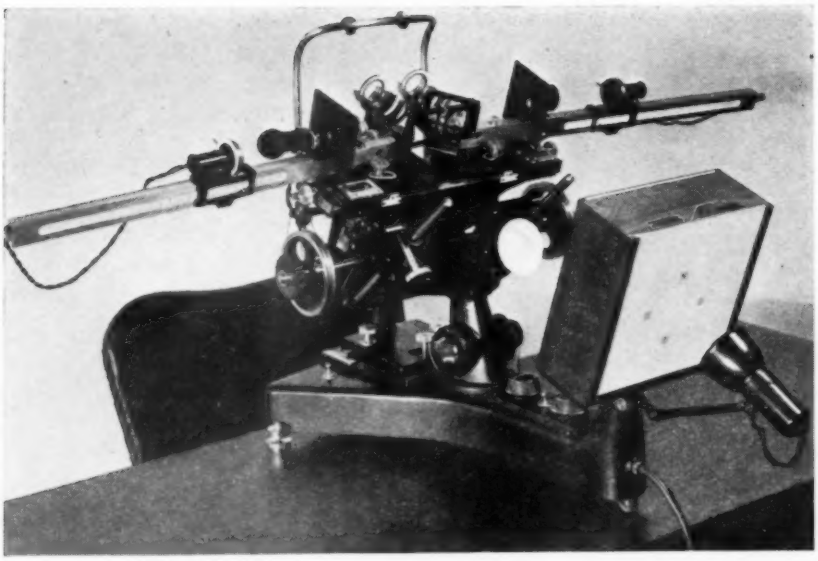


Figure 1.
Ophthalmo-Eikonometer

eikonometer. (Fig. 1.) This instrument combines a subjective test for

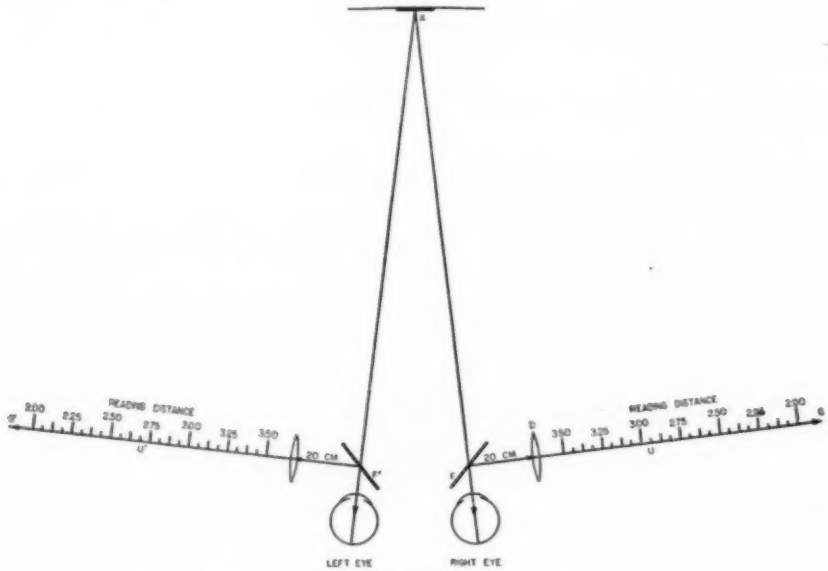


Figure 2.
Refraction Arrangement of Ophthalmo-Eikonometer

the ametropic power correction with a test for aniseikonia. Looking through half silvered mirrors the patient is maintaining single binocular vision for the test distance. In these mirrors are reflected dioptric test objects gliding on laterally extended metal rails. The setting of each test object for best discrimination is recorded on a dioptric scale indicating the character and magnitude of the ametropia. (Fig. 2.) Suitable test objects are used for astigmatic tests. The test is quite exact and allows monocular

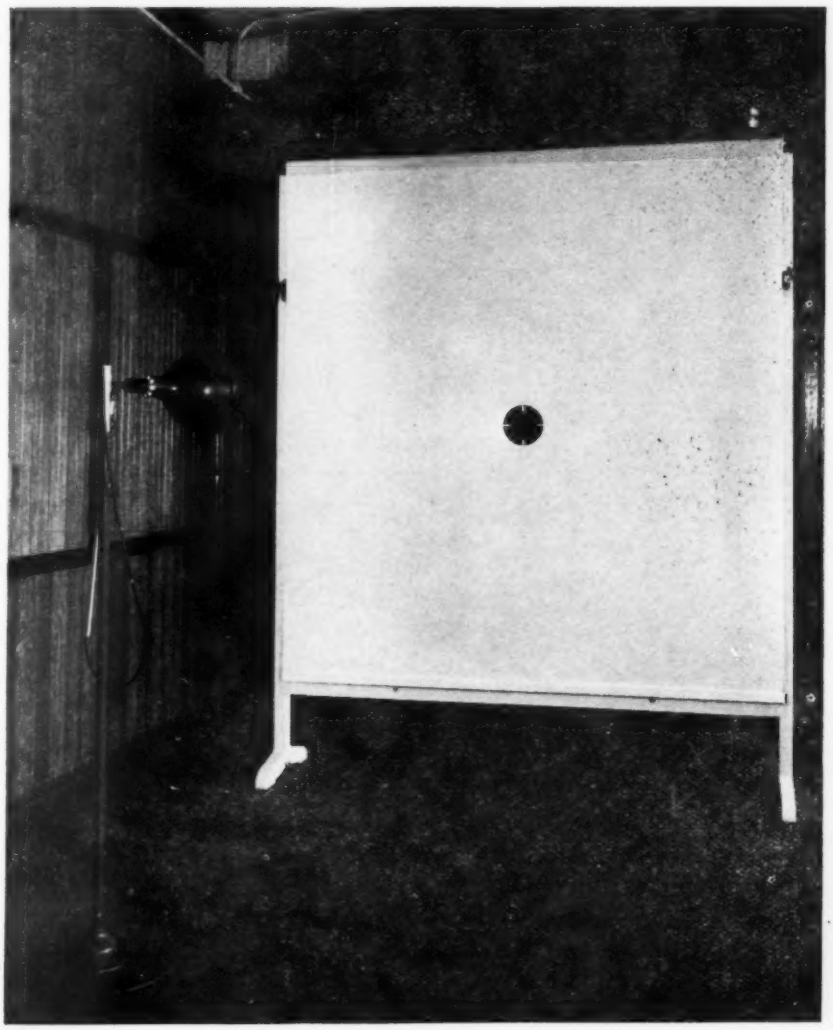


Figure 3.
Front View of the Eikonic Distance Target

subjective refraction while maintaining single binocular vision at the test distance, a feature generally regarded as advantageous.

The aniseikonia test as administered by the ophthalmo-eikonometer is based upon the assumption of persistency of peripheral fusion. On a screen is a central single configuration and at a distance subtending 4° at the cyclopean nodal point of the patient in the four principal directions from the center are four holes in the screen. These holes appear as tiny lights to one eye and as black dots to the other eye. The field of view for each eye is restricted to the screen by means of unlike apertures. The only fusion anchor within the binocular field of view is the central mark on the screen. (Fig. 3.) One may think of the ocular image as being expressed by the number of covered retinal units. When these units are spaced wider in one eye than in the other, then an identical retinal image will be recognized as being smaller when received by the first eye because, on account of the wider spacing of the retinal units in this eye, the retinal image will cover less retinal points than in the other eye. When we turn both eyes laterally the eye with the wider spaced retinal units (smaller ocular size) will have to make a larger angular sweep than the other eye to effect peripheral fusion for the central screen mark. The dots and lights will then not align and by recording the patient's answer the aniseikonia existing in the 90° and 180° meridian is determined. (Fig. 4.) By means

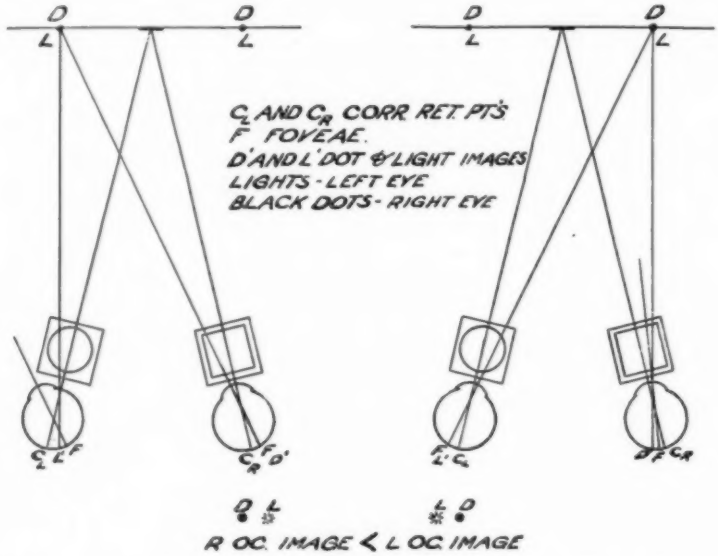


Figure 4. Principle of Ophthalmo-Eikonometer aniseikonia test.

of adjustable size lenses the dots and lights are brought to coincidence and the iseikonic correction determined. We see then that the test is made on a plane perpendicular to the patient's sagittal plane and it is based upon a pronounced definite peripheral fusion hold.

Aniseikonia has been measured and corrected by the Eye Clinic at Dartmouth, two other eastern clinics and two private practitioners for close to seven years and in that time about 2,000 patients have been fitted with iseikonic corrections. The success with these corrections was found to be about 70%. In spite of this remarkable clinical success there is criticism concerning the importance of aniseikonia and the reliability of the method of examination.

Doubts have been expressed in various quarters as to the soundness of measuring and correcting aniseikonic differences of 1% and even less in view of the fact that an asymmetric convergence of the eyes may introduce geometrically size differences many times that amount and that these differences are seemingly overcome without any difficulty. As proof of this contention was quoted the well-known fact that one can read a book held to the right or left from the sagittal facial plane without experiencing any ill effect. Dartmouth explained this fact not by a high aniseikonic tolerance but by a certain amount of image size compensation which takes place when asymmetrically converging the eyes. The evidence in support of this explanation was furnished by the Dartmouth group through very outstanding research, the results of which are published by W. Herzau and K. N. Ogle in Gräfe's Archiv für Ophthalmologie, vol. 137, No. 3, "Uber den Grössenunterschied der Bilder beider Augen bei asymmetrischer Konvergenz und seine Bedeutung für das zweiäugige Sehen." A paper also dealing with this subject will be published in English in the near future.

Since this recent Dartmouth research utilizes the concept of the horopter, it seems advisable to review the influence of aniseikonia upon the horopter.

Corresponding retinal points possess identical relative visual directional values. If the retinal images of an outside object point fall on corresponding retinal points, we have the visual mental impression of single binocularity for this object point. The object point is then located on the horopter for a certain fixation distance. The horopter consists then of intersection points of corresponding retinal point projections with the nodal points of the eyes as projection centers.

Experimentally, the longitudinal horopter is determined by setting a series of vertical rods which glide on rails arranged fanlike from the cyclopean eye until each is seen single binocularly. During the settings, single binocular fixation for the central rod is maintained and the peripheral rods are set utilizing indirect vision. Such a horopter will depend only upon the average longitudinal component visual directional values of corresponding points. As single binocularity occurs as long as the two retinal rod images fall within the lateral extent of the fusion areas, it alone is not a very adequate criterion for determining the horopter. As an added refinement, the sensitivity for disparate images can be utilized by requesting the observer to set the rods so that they appear single and at the same distance as the fixated central rod. After the rods are set according to these criteria, they will appear to the subject as if located in a plane passing through the fixated center rod and perpendicular to the sagittal plane (apparent frontal plane).

The peripheral rods can be exposed to the eyes in two different ways. Either the whole of the rod is visible to both eyes in which case both

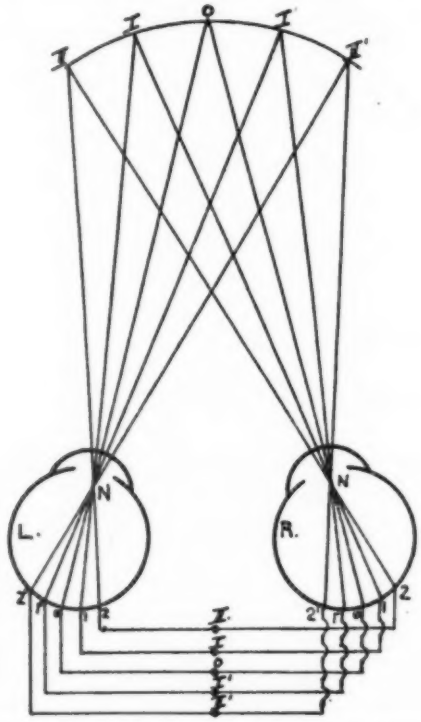


Figure 5. The Veith-Mueller Circle Horoptor.

criteria—identity of visual direction and frontal plane condition—are operative, or the part of the rod visible to one eye is not visible to the other eye (Dartmouth nonius method). In this latter case the rod is to be shifted until the criterion of identical visual direction is fulfilled when coincidence of the monocularly observed parts of the rod is evidenced by the appearance of a continuous unbroken rod.

Assuming perfect equal and symmetrical distribution of retinal elements in both eyes the longitudinal horopter will coincide with a circle passing through the point of fixation and the two nodal points. (Fig. 5.)

In cases of clinical aniseikonia, or that induced artificially by iseikonic lenses, the projection fans of the corresponding retinal points are altered and the longitudinal horopter tilts towards the eye carrying the larger image. By means of an iseikonic lens the projection fans of an aniseikonic case can be equalized and the horopter turned back to a normal position. (Fig. 6.)

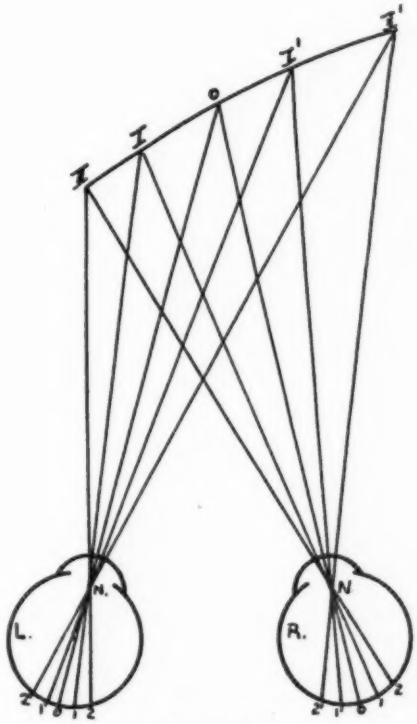


Figure 6.
The left ocular image is larger than the right ocular image. The horoptor tilts to the left.

In the work with asymmetrical convergence, Dr. W. Herzau and Dr. K. N. Ogle served as subjects. The steps of their investigations were:

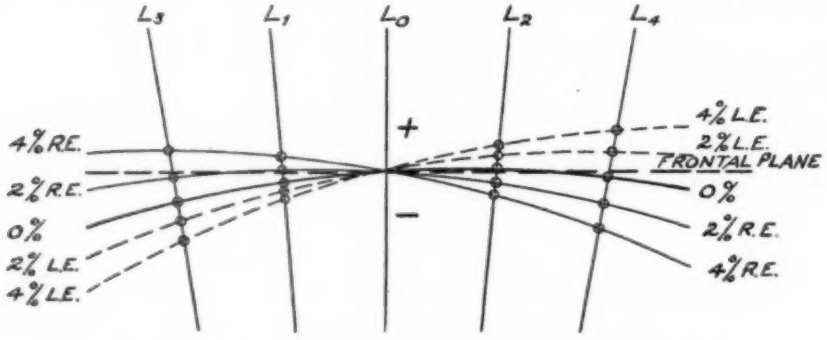
1. Repeating Dartmouth's former research concerning the tilting of the horopter by means of induced aniseikonia (size lenses).

2. Investigation on the horopter of any possible size compensation during asymmetric convergence caused by
   a. Frontal parallel shift of the head.
   b. Lateral rotation of the head.

3. Investigation of any possible size compensation during asymmetric convergence by means of the haploscope.

4. Determination of cause of size compensation by means of after image tests (conducted at Tschermak's Physiological Institute—German University at Prag).

1. As mentioned before, artificially produced aniseikonia tilts the horopter towards the eye carrying the larger image. The geometrically necessary tilt to restore equal visual direction and the apparent frontal



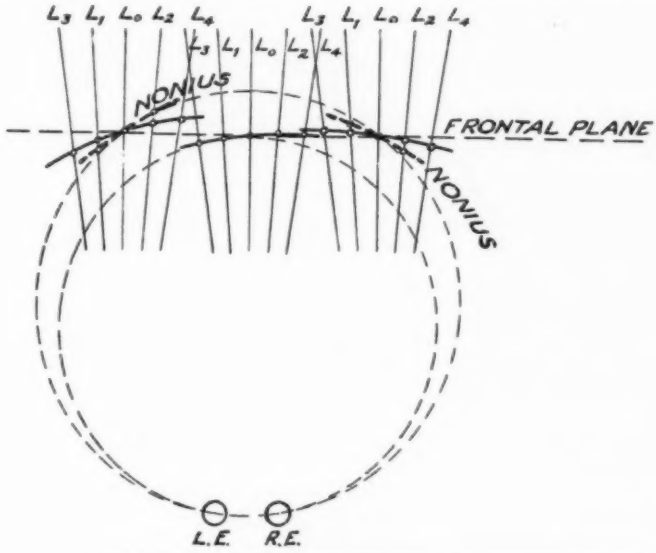
LANE		LEFT FIELD		RIGHT FIELD	
		L_3	L_1	L_2	L_4
0%	Reading MM.	−12.6	−4.1	−0.7	−3.3
	Mean Dev.±	(±0.9)	(±0.4)	(±0.7)	(±1.6)
2% L.E.	Reading MM.	−23.1	−9.5	+5.9	+9.8
	Mean Dev.±	(±1.4)	(±0.7)	(±1.1)	(±1.7)
4% L.E.	Reading MM.	−35.1	−15.9	+12.9	+24.1
	Mean Dev.±	(±1.2)	(±0.4)	(±0.5)	(±1.0)
2% R.E.	Reading MM.	+0.9	+2.1	−6.8	−14.1
	Mean Dev.±	(±1.1)	(±0.5)	(±1.0)	(±1.6)
4% R.E.	Reading MM.	+14.1	+8.9	−13.2	−27.1
	Mean Dev.±	(±2.0)	(±0.9)	(±1.0)	(±1.5)

Figure 7.

Chart showing horoptor readings in symmetric convergence. Fixation distance 60 cm. (W. Herzau.)

plane condition is approached so persistently and closely by the actual settings, that the empirical setting can serve as a criterion for the existing image size difference between the R. and L. eye. (Fig. 7.) Here the natural horopter of the observer shows a slight tilt to the left which is commensurable with the observer's left megaleikonia. The horopter tilts toward the eye with the size lens.

2. The next step was then to investigate the horopter with asymmetric convergence. This asymmetry of convergence was created both by a frontal parallel shift of the head of 2 and 4 times the interpupillary distance to the right or left and by an equivalent lateral rotation of the head to the right or left. Both techniques give about the same results and we shall show here only the data of one experiment of the many



		FUSION METHOD				NONIUS METHOD	
ASYM. HOR.	LANE	LEFT FIELD		RIGHT FIELD		L. FIELD	R. FIELD
		L_3	L_1	L_2	L_4	L_1	L_2
2 P.D. To Right (−19.1°)	Reading MM.	−21.5	−10.3	+8.6	+15.3	−21.6	+17.5
	Mean Dev.±	(±0.6)	(±0.5)	(±0.6)	(±0.5)	(±2.8)	(±4.3)
Symmetric Horoptor	Reading MM.	−9.2	−3.6	+1.5	+0.8	−2.8	+1.9
	Mean Dev.±	(±0.7)	(±0.4)	(±0.3)	(±0.7)	(±1.2)	(±1.4)
2 P.D. To Left (+19.1°)	Reading MM.	+5.0	+3.1	−4.1	−10.7	+14.4	−19.4
	Mean Dev.±	(±0.7)	(±0.3)	(±0.8)	(±0.7)	(±1.4)	(±2.8)

Figure 8.
Chart showing horoptor readings in a symmetric convergence caused by a lateral shift of the head. Fixation distance 40 cm. (Herzau-Ogle)

reported in the German publication by W. Herzau and K. N. Ogle. (Fig. 8.) The theoretical geometric horopter under the condition of asymmetric convergence is again the Veith-Mueller circle determined by the point of fixation and the two nodal points of the eyes. The empirical horopter, provided the lateral rotation of the eyes does not cause any size adjustment and the subject is not aniseikonic, should then appear tangential to the V. M. circle. In reality, however, the empirical horopter is very little turned from the true frontal position which can only be explained by a size adjustment such that the eye receiving geometrically the smaller image is transferring same into a larger image and vice versa.

Fig. 8 gives and shows the data for two horopter settings marked "Fusion Method" and "Nonius Method." As mentioned before, the peripherally observed horopter rods are either seen by both eyes (fusion method) or one part of each rod is seen by one eye while the other part is seen by the other part of the eye (non fusion—nonius method). In the first case the rods are set not according to identical visual direction but by means of the stereoscopic function for apparent frontal plane condition, while in the second case, only the one criterion of identical visual direction is fulfilled. Our every day vision is, of course, subject to both criteria and therefore, size compensation is believed to take place. That the compensation for the size differences induced by asymmetric convergence occurs only when the fusion sense is fully active is significant and important. It is comparable to phorias for which compensation takes place only as long as the fusion sense is active.

In passing, we call attention to the diagram showing how the asymmetrical convergence horopters of the subject (Herzau) reflects his natural horopter tilt to the left (left megaleikonia).

When we observe a square figure which has been displaced to the left parallel to the frontal plane, it is then seen in asymmetric convergence and we notice that geometrically the left eye image is larger than the right eye image. (Fig. 9.) If we denote the quotient of left eye image size to right eye image size by E, we find that this quotient is larger for the horizontal meridian of the square than for the vertical meridian. By turning the square until it is tangential to the asymmetric longitudinal horopter at the point of fixation we could completely eliminate the horizontal meridional size difference. No amount of tilt, vertically or horizontally, would equalize the relative vertical sizes of the left and right eye images. Full compensation in both meridians can, theoretically, be attained only by an ocular image size adjustment in the eye for the

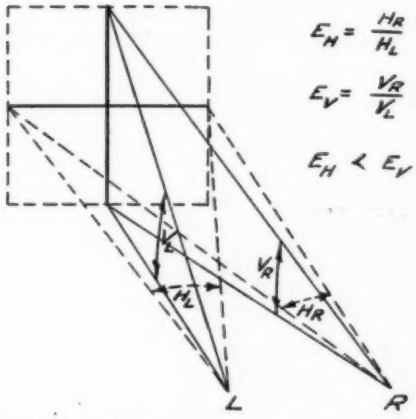


Figure 9. Geometric image size change due to a symmetric convergence.

geometric size difference occurring in the 90° meridian and by a tilting of the square to compensate geometrically for the horizontal and vertical size difference. This is precisely what takes place as revealed by the empirical data.

Fig. 10 shows three curves, C, D, and F. C is the theoretical curve showing the full image size compensation necessary to equalize the vertical dimension. The curve D contains the empirical data showing that the eyes actually slightly over-compensated. The curve F shows the compensation that would be necessary to make the horizontal horopter coincide with the true frontal plane. If such a compensation would actually take place, it would constitute an intolerable over-compensation for the vertical dimension.

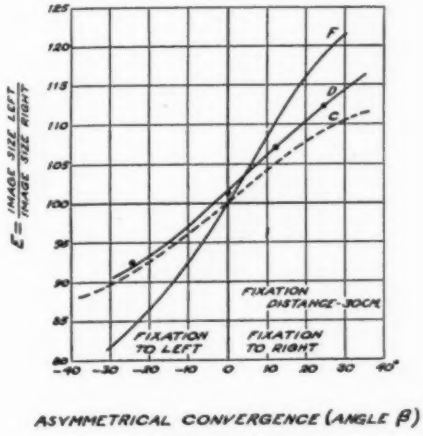


Figure 10.

3. The results obtained with the horopter settings were then checked by tests on the haploscope. Fig. 11 shows the schematic arrange-

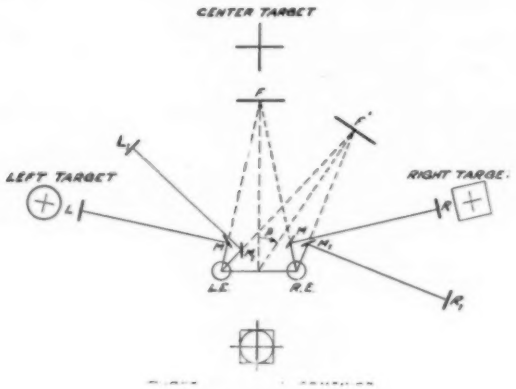


Figure 11.

ment of the two side arms rotating around the center of rotation of each eye and the central arm rotating around the midpoint of the eye rotation centers. The three arms are moving simultaneously to the right or left so that the convergence angle remains constant. On the arms glide targets so that the central crosses fuse and the peripheral non-fusable configurations, circle and square, serve as indicators for any change in ocular image size. By means of iseikonic lenses or by a displacement of the respective side targets on the arms, an equalization of the ocular images can be obtained and the magnitude of the size difference determined.

The data determined by these experiments sustain the results found by the horopter settings. With an asymmetric convergence to the left the eyes make an adjustment effecting a relative increase of the right ocular image size offsetting in the vertical meridian completely the geometrically conditioned minification of the right retinal image.

Therefore, the fact that asymmetric convergence introduces unequal image size conditions of considerable magnitude cannot be used as an argument for extensive aniseikonia tolerances because this research work shows that some type of a compensation takes place which tends to equalize those conditions.

4. The important question to answer is "What is the mechanism of this compensation?" One assumption is that this compensation is of dioptric nature or caused generally by a true physical adjustment. Another would be that this compensation is of sensorial nature so that the mental

visual spatial interpretation is changed with a rotation of the eyes from the primary position.

The answer to this question was supplied by the research of Dr. Herzau at the Physiological Institute in Prague. Professor Tschermak having become interested in this question invited Dr. Herzau to carry on the necessary research in the Physiological Institute of the German University at Prague. This investigation was carried on by means of after images created by intensive stimulation of retinal elements. After images are independent of any subsequent dioptric or physical ocular adjustments but can only be influenced by any central, i.e., interpretative mental changes.

Preliminary investigation showed that 4% or more aniseikonia after images can be discriminated. The geometric image size differences created by asymmetric convergence are far beyond 4% and therefore the after image test is quite acceptable as a criterion. As targets for the creation of after images were chosen uniocular half configurations which, when fused, combine to a full square or circle. (Fig. 12).

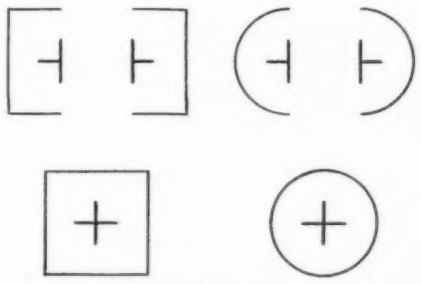


Figure 12.
After image targets for aniseikonia. A symmetric convergence investigation. (Herzau-Ogle)

The following results were obtained:

After images forming perfect combinations in symmetric convergence maintained this fit for any eye rotation from the primary position. The mental visual impression was therefore not changed by version of the eyes.

Uniocular after images created during asymmetric convergence revealed the expected geometrically conditioned size difference of their components and maintained this size difference during version of the eyes.

From the results of this research it is evident that the compensation for geometrically uniocular unequal size images in asymmetric convergence is of dioptric or physical nature and is not caused by a change of the mental visual spatial interpretation. There is a possibility of explaining this compensation, partially at least, by assuming a yet unproven unequal accommodation conditioned by the asymmetric convergence.

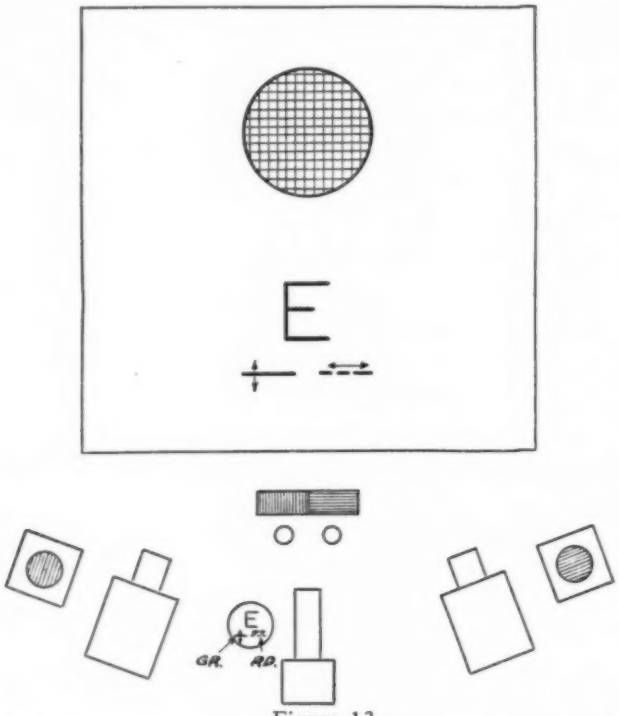


Figure 13.
Diagram showing the experimental set-up used by Professor Ames in his investigation of peripheral fusion.

The second criticism of aniseikonia was directed against the assumption that during the aniseikonia test with the ophthalmo-eikonometer, peripheral fusion of a central target held the relative positions of the eyes. As pointed out at the beginning of this resume, the centrally located black circle acts as a fusion anchor in the peripheral retina when the patient determines by foveal fixation the relative location of the lights and dots. Possibly the unawareness of any doubling or fusion difficulties in the periphery was the main spring of this criticism. Based upon the assumption that the peripheral fusion hold executed by the black center circle is negligible, it was attempted to explain the lack of coincidence

of dot and light point by conceiving a difference in uniocular excursion with a rotation of the eyes from the primary position. As this would mean that the lateral phorias would change with a lateral sweep of the eyes, the phenomenon was given the name "anisophoria."

During the last year or so the ingenious experimental methods used at Dartmouth have shown that the peripheral fusion hold is a very definite and real occurrence. The report of this work has been read before the Ophthalmological section of the A. M. A. a week ago and will be published soon. We shall therefore only report the general experimental setup.

For the experiment two lantern slide projectors and a Project-O-Chart lantern were used with an aluminum painted large screen at a distance of about 15 feet. (Fig. 13.) By means of the two lanterns identical figures were projected upon the peripheral part of the screen, one of which was polarized at axis 90° while the other was polarized at axis 180°. These two targets were brought to coincidence. On the center of the aluminum painted screen was projected by means of the Project-O-Chart a non-polarized test symbol and red and green marks for diplopia and suspension control polarized at 90° to one another. The subject wears polaroid glasses with their axes at 90° and 180° respectively. Thus the left eye of the patient sees the peripheral target projected by the left lantern and the red polarized control mark projected by the Project-O-Chart, while the right eye sees the peripheral target projected by the right lantern and the green control mark from the Project-O-Chart slide. Both eyes will see the non-polarized central test symbol. By shifting one projector in reference to the other, diplopia for the peripheral test targets is created but due to its peripheral location will be entirely unnoticed by the subject. Automatically the eyes will make the necessary adjustment to re-establish peripheral fusion which can only be achieved by sacrificing foveal fusion as exemplified by doubling of the central test symbol and relative shift of the red and green central marks. By varying the distance between the central and peripheral targets and the size and illumination of each, one can quantitatively determine the influence of peripheral upon foveal fusion. (Neumueller demonstrated this phenomenon by means of special stereoscopic cards.)

These results would indicate that in the present test for aniseikonia on the ophthalmo-eikonometer, the peripheral fusion is adequate to hold the relative positions of the eyes, so that accurate measurements of the relative image sizes can be made.

Thus, it is believed that the two most frequently heard criticisms of aniseikonia, namely, that the geometrical image size difference that occurs with asymmetric convergence at near causes no ocular disturbances and that it is questionable whether the peripheral fusion hold is strong enough for accurate measurements, have been met by these experiments.

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DISCUSSION

DR. FRY: If the compensation which takes place with asymmetrical convergence depends upon an adjustment of the ocular mechanism, what explanation can then be given the fact that the nonius horopter doesn't change with asymmetrical convergence but coincides with a fused frontal plane horopter?

DR. NEUMUELLER: When Dr. Fry says the nonius horopter he means the Dartmouth nonius and not the German nonius horopter. The main difference is one of procedure. As was mentioned in the paper, the peripherally observed horopter rods are either seen by both eyes (fusion method) or one part of each rod is seen by one eye while the other part is seen by the other part of the eye (non fusion-nonius method). The fusion method would appear to be the better criterion. Relative to that point, Dr. Beitel has made some interesting investigations. The criterion for the measurement of a phoria is dependent upon your measuring intrument or rather upon the units used in measuring. If cards are used, with the fixation targets so placed upon them as to make possible a large group effusion, the phoria measurement becomes highly inaccurate. For example: If the ordinary card, with a single partition object in the center is used, turning the prism one-half or one degree will cause a displacement of the vertically aligned targets, however, if the same card is used, but with a complex pattern drawn on the background, super positioning of the diplopic images can be maintained though the prisms be turned through as high as twenty to thirty diopters. So the criterion for accurate measurement is certainly dependent upon the peripheral pull.

DR. FRY: I believe I see the fallacy of the point I presented there. Professor Tschermak's work would indicate that it is the asymmetric presentation of the targets that produces the size difference of the images and not changes which occur in the ocular mechanism.

DR. HALL: Dr. Neumueller, it is interesting to note that in your paper you mentioned the tilting of the horopter when an aniseikonia was artificially produced. This then might offer another explanation of the stereo-phenomenon noted by Pulfrich. In that experiment, it would seem we have induced a megaleikonia which cannot be compensated for rapidly enough to dissipate the apparent changes in size and position.

THERMINON & THE THERMOLUX*

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Minneapolis, Minn.

For many years the opinion has prevailed that certain portions of the spectrum were capable of producing injury. Sir William Crooks at the beginning of the century produced a lens whose chief assets were a low transmission in the ultra-violet end of the spectrum and a sharp cut off in the yellow. The yellow, having the greatest luminous flux, the thought must have been to reduce light intensity, where the flux was the greatest. If this gave rise to the thought that a specific wavelength in the visible spectrum was injurious, no research made since then has ever substantiated this theory.

The phenomenon of fluorescence has been invoqued as of significance in the etiology of cataract. But fluorescence is an optical phenomenon apparently inducing no physiological or pathological changes.

Fluorescence can only be caused by the longer ultra-violets as the shorter wavelengths cannot traverse the cornea, and late investigators such as Voght have proven that ultra-violet rays longer than 314 millimicrons can cause no injury.

Neumueller (1) has made careful tests and reported that slight shades of tinted lenses had no effect on visual acuity, that darker shades because of the reduction in light intensity reduced visual acuity, and that therefore merits of tinted lenses must be considered not for the effect of such lenses on visual acuity, but for their physiologic effect because of their absorption of the ultra-violet and infra-red ends of the spectrum. In an article published in this Journal, the author reviewed authoritative opinions on the subject. Sifting of this opinion reveals

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*An abridgement of the material presented before the Iowa State Optometric Association at Des Moines, Ia., April 2, 1939.

Submitted for Publication April 4, 1939.

that while shortwave ultra-violet in concentrated quantities has produced experimental injuries in animal's eyes, only infra-red in normal quantities has been found capable of producing pathologic changes in human eyes. Important is the discovery of Roggenbau and Wetthauer that while all media of the eye absorb infra-red rays, the crystalline lens absorbs 25 to 30% of the rays between 1000 and 1200 milli-microns. This coupled with clinical experience on occupational cataract is more than suggestive of the etiology of heat in the formation of senile cataract.

Ryer and Hotaling, (2) in this Journal have stated all possible facts that could be used to bolster this viewpoint, namely:

1. That senile cataract is on the increase.
2. That senile cataract is an eventual certainty for any one living long enough.
3. That cataracts are not cured, they are retarded or extirpated.
4. That the future course lies in the prevention of cataract.
5. That there is no relation between luminous flux and energy and actual heat as generated by infra-red rays in eye tissues. (Stated in different terms.)
6. That the crystalline is 35% protein.
7. That heat coagulates protein.
8. That prevention and retardation of cataract should be obtained by the constant use of heat excluding glass.

An objection to dark heat absorbing glasses is the fact that when ground to medium and high powers, or in bifocal form, the density of shade is not uniform throughout the lens. Ryer and Hotaling as reported in their article, have obviated this difficulty by grinding down a Calobar lens and fusing it onto a main crown body unto which a correction is ground. We thus have a lens of high power, for instance a high minus, of which only one millimeter thickness is heat absorbing.

The result is a uniform color, but what they fail to point out is that the heat transmission is increased due to the thinner heat absorbing portion. Thus more heat enters the eye.

The following general formula may be used to compute relative transmissions:

$$T_1 = T \frac{l_1}{l}$$

Where T = Transmission for a known thickness.

T_1 = Transmission sought for another thickness.
1 = Known thickness.
1_1 = Thickness for which transmission is sought.

According to this, if a lens like Calobar transmits 39% of heat rays when 2mm. thick, the same glass 1 mm. thick transmits 72%, which is an entirely different story.

This formula does not take into consideration surface losses, but is close enough to illustrate the point.

Another desideratum therefore of former heat absorbing lenses was, that they be thick enough to absorb a substantial portion of heat producing infra-red rays.

The use of heat excluding glass in opthalmic practice is comparatively new. In the last few years efficient absorbents of heat have been presented to the professions under various trade names and in cases of cataract have been used with gratifying results. (3) The chief objection to these heat absorbing lenses is that the very same cases who are to benefit from their heat excluding properties are incommodated by their low light transmission.

Most cataractous patients require increased illumination indoors because of opacities; to deprive them of the protection afforded by heat excluding glass indoors for the sake of visibility defeats the purpose in mind.

To reiterate, if prevention lies in the constant wear of heat absorbing glass, retardation should also require the constant wear of such glass. Artificial illumination contains a higher percentage of heat rays in proportion to the luminous flux than outdoor light. The pupil is regulated proportionately to the luminous flux and the retinal adaptation; it follows therefore, that due to reduced indoor illumination, adaptation and the spectral composition of artificial light, a much higher percentage of infra-red rays enter the eye for equal visual response under artificial illumination.

In the difference between radiant flux and luminous flux may lie differences of opinion or rather an indifference to infra-red rays. Radiant flux is the rate of energy radiation; luminous flux, the rate of flow of light as it affects visibility.

Color temperature is the heat to which a perfect black body must be raised to emit certain colors, but the actual temperature of a source

of light may have nothing to do with its color temperature. Thus it is that while visibility and energy radiation have a relationship, the actual radiation of heat in the form of infra-red rays has little to do with body temperature or energy emmision.

And so in attempting the prevention or retardation of cataract by shielding the eyes from spectral radiation, we are too prone to alter the visible spectrum without a proportionate effect on the invisible infra-red spectrum.

The convertible heat contained in the visible spectrum is negligible compared to that in the infra-red and the visible spectrum is necessary for normal visual function.

Artificial illumination to which we are today exposed most of the time is a relatively greater source of infra-red radiation than outdoor illumination. Therefore for the prevention and retardation (not to say "cure") of cataract, it is necessary to use a glass that will absorb a maximum of infra-red rays, transmit a maximum amount of light and produce as little alteration of color values as possible.

Over a period of years, the fact that the human does not respond equally to all wavelengths has been recognized and the collective observations of skilled observers have been gathered and constructed into a curve adopted internationally as the "standard spectral sensitivity curve of the eye." This curve represents the sensitivity of the human eye for various wavelengths. Naturally it is highest in the yellow and lowest in the violet and the red regions.

Some manufacturers have reproduced the transmission curve of their glass and superimposed the sensitivity curve of the eye, then proudly pointing to an apparent similarity between two curves, claim that because the visual transmission of said glass is similar to the sensitivity curve of the human eye, there can be no color distortion.

Unfortunately spectrographic analysis determines radiant flux and this differs from luminous flux. One analyzes the physical components of light, the other evaluates the visual response to 100% transmission of these components so that if radiant flux is altered by a filter, a color alteration must take place regardless of sensitivity of the observing eye.

The transparency of this claim is obvious when anything is viewed through the glass. Color values are changed proportionately to the shade.

To obtain a minimum of color value change glass should transmit

radiant flux in the same proportion that it receives it. No glass does this perfectly, hence all glass has color and all glass causes a relative change of color values, even though slight. An absorption glass that transmitted all colors (radiant flux) evenly would have no effect on colors, but would make objects seen through it appear darker. Tcherning's neutral filters, now available in Wratten wedges transmit colors fairly evenly.

The spectographic graph of such a glass would be a straight line. Within limits of the visible spectrum, the more curved or bent this curve is, the greater the attendant change in color values.

THERMINON

In a previous article (4) published in this Journal last year the writer reported the analysis of a new glass, made at the University of Minnesota in the Physics Department. The analysis proved that the glass in question was an efficient absorber of energy and yet had a relatively high light transmission.

The figures for a sample 2 mm. thick were:

Light Transmission	92%
Heat Transmission	51%

The analysis was confined to spectographic measurements of the new glass for the visible part of the spectrum.

Previously the American Optical Co. had made an analysis of its ultra-violet and infra-red transmissions. The three portions were intergrated and the result was the transmission curve shown in the said article. Since then this curve has been reconstructed on a compressed scale for convenience and it is here reproduced. (Fig. 1.)

To this curve has been added (dotted line) an estimated heat intensity curve of the spectrum as it affects the human eye. We hasten to state that no conclusion is to be drawn from the juxtaposition of these two curves. The dotted line is merely a graph of relative heat intensity when a thermocouple is exposed to radiations of various wavelengths. This new glass has since made its appearance commercially and is available to the optical industry under the trade name of "Therminon," (heat resisting).

Therminon at first proved difficult to work optically. Certain alterations in hardness, index of refraction, melting point at to be made to permit grinding into lenses. Further tests show that these alterations did not affect its heat absorption properties.

No color had been contemplated. The prime objective was heat absorption, but the ingredients which cause the molecular structure responsible for the heat absorption also produce a pale greenish blue color resembling that of other glass. Best evidence of the accidental nature of its color is the fact that Therminon and one other glass can hardly be told apart by inspection, yet the crudest thermometer will show a marked difference in heat transmission of the two lenses.

The unusual performance of Therminon naturally suggested further investigation in the absorption of light and heat by various lenses.

The first and most important basis of evaluation in a heat absorbing lens is: How much light does it transmit? If only heat absorption is wanted, by excluding most of the visible light fairly good heat absorption is obtained. In fact a semi opaque lens will show considerable heat absorption more or less as a cataractous crystalline lens will absorb more heat than a healthy transparent one.

Our first consideration therefore is light.

Secondly, of what importance is heat? We have seen that heat is thought to be the cause of occupational cataract, that it is an important factor in the development of senile cataract, that it can produce retinal and even choroidal injuries and that it is thought to be the cause of sun blindness (5).

Some of these opinions can be proven clinically. Senile cataracts can be arrested as Ryer and Hotaling have done.

Relief of photophobia by Therminon is an everyday experience. Incipient cataract patients are quick to note the difference and aphakic patients experience great and immediate relief.

Raggenbau has physically determined that the crystalline lens absorbs 25 to 30% of rays between 1000 and 1200 milli-microns. When the lens is removed, these rays strike the retina producing sun blindness and sensitivity to artificial light.

The subjective evidence confirms the objective findings.

THERMOLUX

Visible light can be measured from two standpoints.

The radiant flux or energy output of a source.

The luminous flux or visibility of a source of light.

The energy of light may be actinic, visible or heat energy. It is the

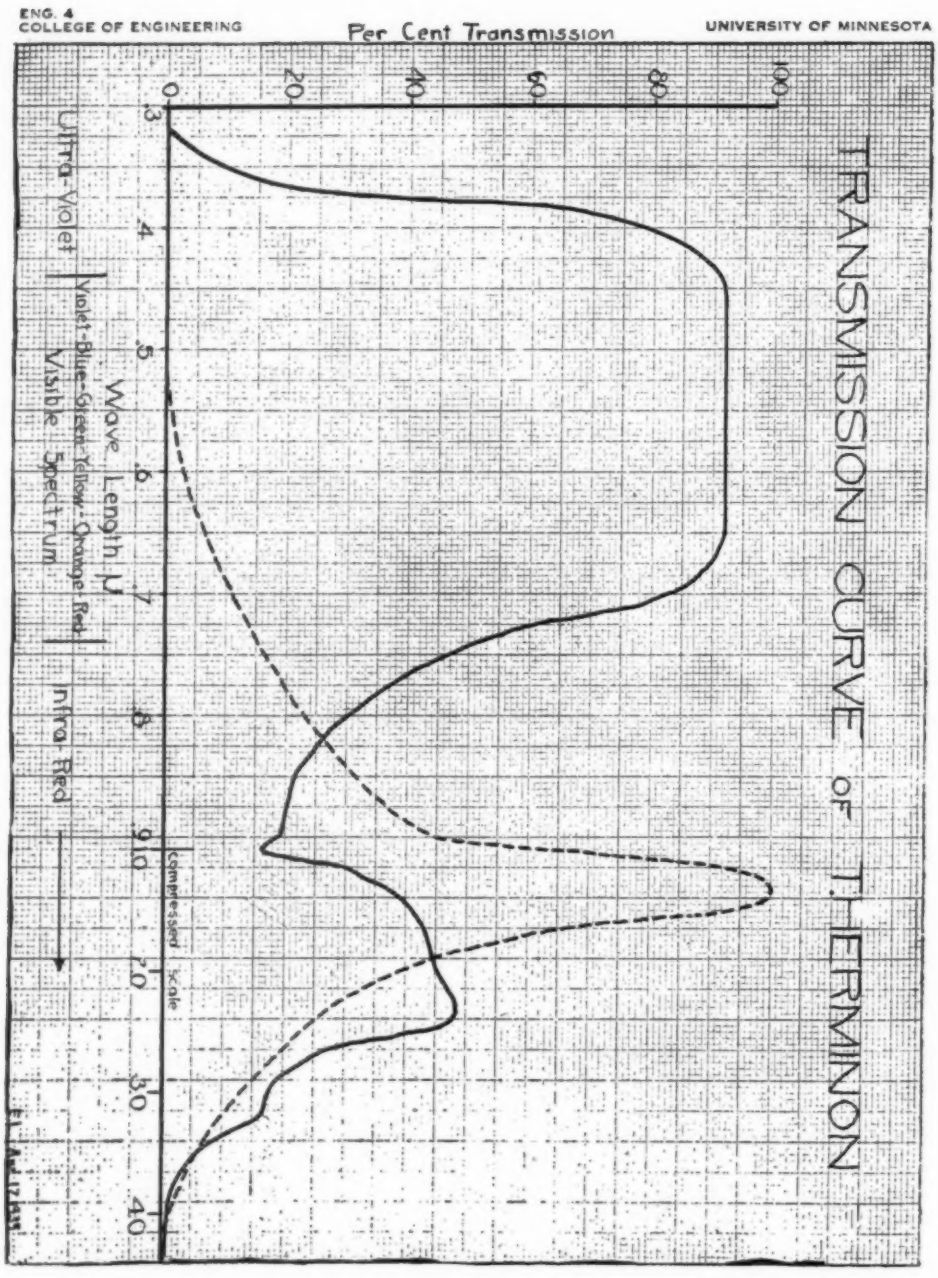
ENG. 4
COLLEGE OF ENGINEERING
Per Cent Transmission
UNIVERSITY OF MINNESOTA
TRANSMISSION CURVE OF THERMINON
0
20
40
60
80
100
.3
4
5
6
7
8
9
10
20
30
40
Wave Length μ
Ultra-Violet
Violet-Blue-Green-Yellow-Orange-Red
Visible Spectrum
Intra-Red
compressed scale

Figure 1.

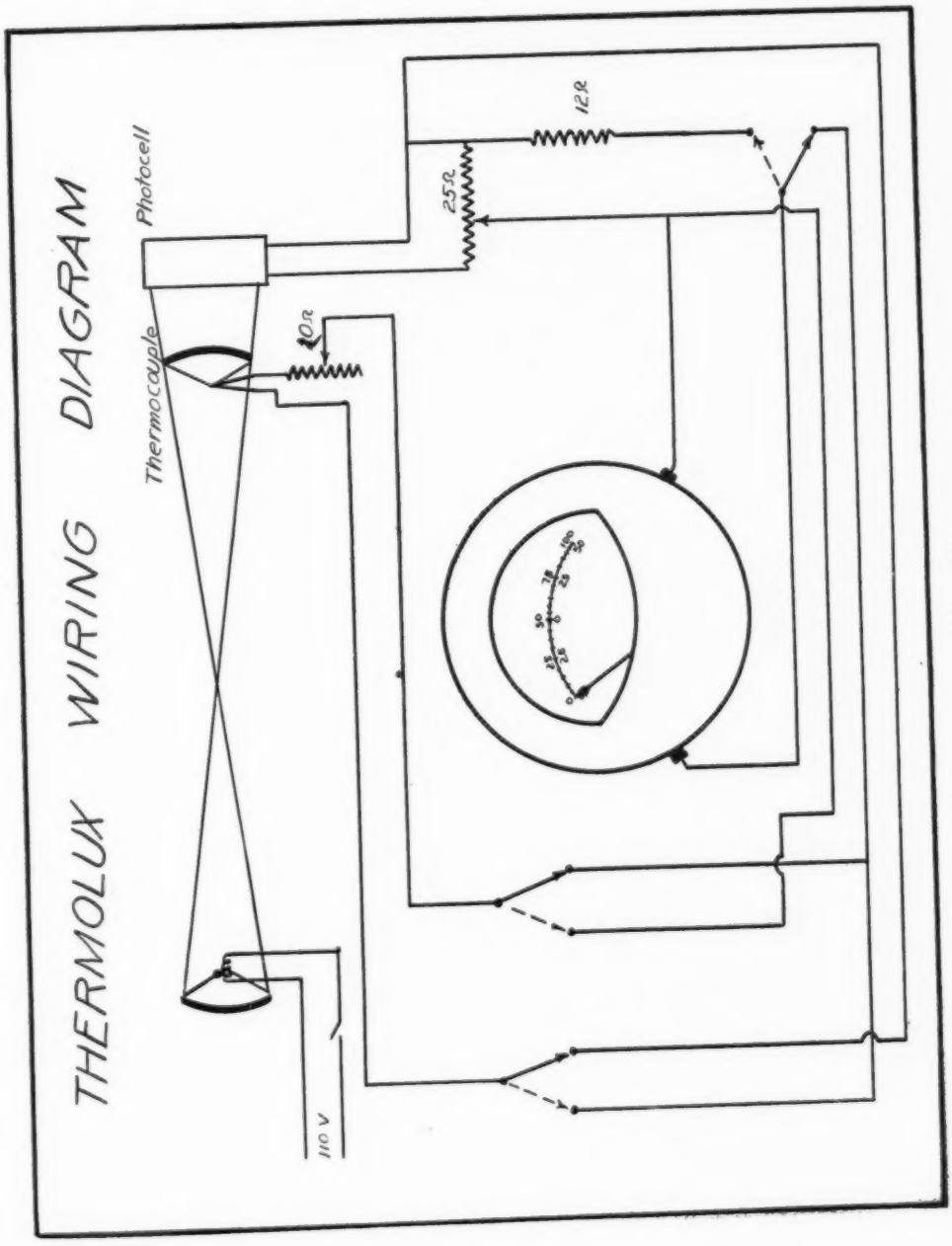
THERMOLUX WIRING DIAGRAM
Photocell
Thermocouple
12Ω
25Ω
10Ω
110 V

Figure 2.

sum total of light emmission. The luminous flux is that part of the spectrum affecting brightness as seen by the human eye. The eye does not respond to all wavelengths. This does not mean that altering the blue end of the spectrum will not cause a change of color values because the eye does not respond to the blue as it does to yellow. It means that the radiant flux being the same, the luminous flux is greater for the yellow than for the blue.

A spectrographic analysis having been made, and this showing a visible light transmission of 92% for Therminon, it was thought that a comparative study of various lenses by means of a "Photronic" cell would prove interesting.

The ordinary photo-cell does not measure light in proportion to radiant flux and the fact that it is sensitive to heat prevents it from being an accurate measure of luminous flux. But a recent development in the form of a filter known as a "Viscor" filter, a product of the Weston Laboratories, makes the photo-electric cell response identical to the sensitivity curve of the human eye. There is less difference between the cell response and the International Sensitivity curve, than there is in the response of various human eyes. It follows therefore that while a Viscor equipped photocell does not measure light transmission in the same manner as the spectrograph, it provides a true measure of light transmission as affecting the visibility of the human eye.

The photronic cell generates its own current when exposed to light. No battery is needed. This current is a direct current, it has polarity and the current generated is almost a linear expression of the light impressed upon the cell when the external circuit resistance is low.

The photronic or photo-cell does not measure heat, and with a Viscor filter is completely insensitive to infra-red rays.

To measure heat a thermocouple can be used. This device consists of fine wires of different metals joined together in a vacuum. One joint is known as the cold end and remains at room temperature. The other is the hot end and when it is exposed to a beam of light, a current is generated flowing from the cold to the hot, to the cold, etc., around in a circle through the close circuit. This current is also a direct current and for low temperature difference is a linear function of the heat. By introducing in the circuit a sensitive meter, a true measurement of heat transmission is obtained.

The meter we used in this case registers at full scale ½ millionth of a watt. The apparatus (Fig. 2) is arranged so that light from a 50-watt projection bulb falls on the thermocouple and on the photo-cell. The meter can be thrown into either circuit by means of a single pole, double throw switch. The Thermocouple and photo-cell each have a variable resistance so that the bare light beam will register full scale on the microammeter, for either heat or light measurement.

When a lens is placed in the beam its light and heat transmissions can be read directly on the meter.

A relative light transmission reading can be obtained by adjusting the photo-cell resistance so that the meter reads full scale after light passes through white crown of known thickness. Then by testing various colored samples of the same thickness, the effect these colors have on light transmission can be determined. The same thing can be done with heat transmission. The first most obvious conclusions on this device are as follows:

1. That white crown absorbs light and heat proportionately to its thickness.
2. That this absorption is inconsequential.
3. That pinkish tinted lenses transmit less light than white crown, and either the same amount of heat or slightly more.
4. That greenish or bluish glass absorbs heat proportionately to the density of the shade.
5. That those green lenses that are efficient absorbent of heat are poor transmitters of light.
6. That Therminon is an efficient absorbent of heat and has a good visible light transmission comparable with the lighter tints.

A further development was the simultaneous measurement of heat and light transmission to obtain a measure of relative efficiency.

Let us restate: We want more light and less heat transmission, or to state it differently, more light transmission and more heat absorption. By means of a double pole, double throw switch the current generated by the thermocouple is reversed so that its polarity is opposite that generated by the photo-cell. The circuit is balanced at the middle of the scale on the micro-ammeter thus using it as a galvanometer. The two circuits thus oppose each other, so that when the heat current is reduced, it is equivalent to a rise in light transmission current.

With this setup, white crown shows practically no change. It reads neither loss nor gain of efficiency.

Tinted lenses show a definite loss of efficiency, the dark shades even going off the scale. Heat absorbing lenses vary in their showing. They show up better because they make up their low light transmission by substantial reduction of the heat (thermocouple) current.

Of the twenty odd glasses tested to date only Therminon shows a decided gain in efficiency. This is thought to be because in that glass only is the heat absorption out of proportion to, and not dependent on its color. The molecular structure of the glass differs from crown sufficiently to cause a disproportionately low heat transmission and high light transmission. The most striking evidence of this disproportion is a comparison between Therminon and another glass now in use and of almost identical appearance. The two samples ground to the same thickness can hardly be told apart. Yet when tested on the balancing circuit described above one lens shows a big loss of efficiency to the left of zero on the meter scale. Therminon shows a bigger gain of efficiency to the right of zero. This holds true for any thickness or power of lens. This device therefore provides a quick and reliable method of identifying Therminon heat absorbing glass from other glass of similar appearance, but different physical characteristics.

It also offers a method of analyzing various ophthalmic glass and provides a check up on the diversity of claims made for some of our much advertised lenses. The device offers interesting possibilities and will be available to the professions soon under the name of "Thermolux."

We hope to be able to present in some future issue of this Journal the results of tests made with this apparatus on various samples of glass now in common use in the optical industry.

SUMMARY

1. This and a previous article summed up prevailing opinions of injuriousness of radiation.
2. The consensus of opinion is that, of all parts of the spectrum, infra-red is not only the most injurious but also the only part capable of producing injuries or pathologic changes, particularly cataract.
3. That in logical pursuance of our occupation we must direct our attention to the heat absorbing properties of opthalmic glass, especially in certain cases such as cataract.

4. A new glass, an efficient absorber of heat with a high light transmission is available under the name of Therminon.
5. An apparatus has been devised to identify this glass and to measure heat and light transmissions of any glass as well as its relative efficiency.
6. The peculiar property of Therminon to absorb heat and yet transmit a high percentage of visible light not only makes this glass desirable in cataract and aphakic cases but also practical for general use for preventive reasons and for general comfort.

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REFERENCES

1. Neumueller, Julius—Variations in visual acuity with various absorption lenses. American Journal of Optometry, February, 1936.

2. Ryer, E. LeRoy and Hotaling, Elmer E.—A New Absorption lens for Use in Selected Cases of Senile Cataract with Negative Histories. American Journal of Optometry, July, 1937.

3. Ryer, E. LeRoy and Hotaling, Elmer E.—Report: Red free glass in certain cataract cases. American Journal of Optometry, May, 1935.

4. Du Plessis, Guy L.—A new type of absorption glass. American Journal of Optometry, June, 1938.

5. Mindt, Walter—Report on the latest ultra-red and ultra-violet researches on human and animal eyes. Proceedings of the International Optical Congress. Cologne, July, 1928.

MYOPIA AND MUSCLE IMBALANCE*

H. W. Gibson, F.B.O.A., F.S.M.C.

It is quite conceivable that the increasing prevalence of myopia will become a matter of grave concern to the authorities responsible for the nation's health. There can be little doubt that the disease is a physical result of an increase of industrial occupation and most probably intensive education of the masses. The average boy or girl of today is compelled to devote much more time to study than the youth of previous generations in order to equip themselves to take their place in the modern highly scientific world of commerce. It cannot be denied that the excessive close work and concentration demanded by the highly organized mass-production methods on the one hand and concentrated research on the other are important factors in the production of the disease. Considerable attention has been paid to factory lighting conditions it is true, but efficiency systems are now the vogue and these demand close concentration on the work in hand for long periods of time on the part of the operative. Moreover, health authorities can never hope to control conditions under which "midnight oil" is burned, neither can they limit the hours of study of the individual.

The development of myopia cannot be predetermined although hereditary influences in some cases are no doubt responsible for its origin. Many children of myopic parents escape the disease, however, while myopia not infrequently develops in children in whose family history no trace of myopia can be found. But apart from any consideration of hereditary influence the condition is always, in the early stages at least, progressive. It is the duty, therefore, of those engaged in ophthalmic practice to endeavor to formulate a procedure which will, if possible, prevent its inception, or, at least, check its progress. With this end in

*An abridgment of the material appearing in the Optician, Vol. XCVII, No. 2498, pp. 3-5, 1939.

view every associated feature must be investigated in an endeavor to ascertain its connection and influence on the disease itself.

The etiology, causation and treatment of myopia has been the subject of more contentious literature than any other in ophthalmic practice, and the individual practitoner attempting to find a solution of the problems confronting him finds his path strewn with difficulties. In the first place, the results of any experimental treatment can only be proved over a number of years; secondly, the average practice cannot provide material sufficient for conclusive evidence, and finally, few children and young adults are willing to undergo treatment for more than a few months because it invariably interferes with study. The logical remedy, therefore, is collective research by hospitals, clinics, and study groups. Nevertheless, experiments conducted by individual practitioners, even if only on a small scale, may help to throw light upon the problems and prove of value. The object of this paper is to report on an experimental procedure based on the effect of muscle imbalance on myopia which has achieved a certain degree of success.

The effect of muscle imbalance on myopia is by no means an original subject, and treatment by orthoptic exercises and prisms has been advocated from time to time but methods of treatment vary in accordance with the views held by their exponents. In advancing the procedure outlined the writer is well aware that the results obtained, although successful, cannot be considerd conclusive until proof has been obtained of its success in a considerable number of cases.

As previously stated the causation of myopia is obscure and while a certain percentage of cases may be due to an hereditary disposition it is obvious that the majority are developmental, especially in those of low degree. Few children are born myopic and therefore the disease is one which develops with growth, except where it is a direct result of a pathological condition of the body.

There are, however, a few generally accepted factors which emerge from the published investigations of various authorities. To commence with it is established that in axial myopia the sclerotic coat of the eye is stretched and weakened; also that the construction of the myopic eye differs from the normal in as much as the fibroblasts have a different or so-called "faulty" disposition. Whether this difference of construction permits the stretching or is the direct result of it has not been determined, but the fact remains that it is a constant feature. It is also

agreed that the development of myopia is influenced by close work, although the disease is occasionally found in agricultural workers who are not habitually engaged on close work, but in these cases it is almost invariably found that there is an hereditary tendency. One other factor is the prevalence of muscular imbalance and a particular kind of imbalance, namely exophoria. The prevalence of exophoria accompanying myopia is not denied, and in many cases where it is not manifest at the first examination it is revealed after a period of occlusion. Examination of a large number of records by the writer revealed that over 75 per cent of myopic cases were accompanied by exophoria, while esophoria was very rarely found. Such an important feature cannot be ignored as it is almost constant.

Hitherto the tendency has been to regard exophoria as a result of the development of myopia, but it is quite within the bounds of possibility that myopia is in some measure due to exophoria. Muscular co-ordination of the two eyes undoubtedly takes place at an earlier stage in life than the attainment of binocular vision, and therefore it would appear that as fusion of the two neural images is achieved a slightly imperfect balance is overcome, resulting in heterophoria. The small defect in co-ordination may, at this stage, result in a blurred single image and the child in an attempt to obtain clearer vision increases the angle by approaching the object nearer to its eyes. Thus, where the imbalance is exophoria an excessive convergence effort is produced. This excessive convergence effort is not likely to seriously affect the development of the eye in the very early years of childhood because it is not until the child's education is commenced that great demands are made upon convergence. The age on onset of myopia is reputed to be from five to twelve years and it is significant that at this period of life a considerable part of the child's day becomes devoted to close work.

A study of comparative anatomy reveals that nature adapts the construction of the eye of the animal to meet its primary visual requirements, e.g., if it is of first importance for the animal to possess a wide panoramic field of view the eye is so constructed to furnish it to the exclusion of an acute perception of detail, but if perception of detail is of primary importance then the eye is constructed so that it can be achieved in preference to any other attribute. It has also been established that, in man, if a continual strain is placed on any particular part of the body through occupation or habit a change takes place in the con-

struction of the body in order to minimize the effect of the strain. It would appear logical to assume, therefore, that if considerable demands are made on the physique of the child through the habitual observation of objects situated at a closer distance to the eyes than is normal, nature so alters the construction of the eye so that perception of near objects can be achieved in comfort. Examined from this point of view the theory that, where excessive demands are made on convergence and where there is a weakened sclerotic coat, the abnormal pressure exerted on the globe of the eye by the external recti muscles causes the substance to stretch and the globe of the eye to become elongated.

Up to this point the effect of convergence on myopia has been considered purely as a separate function, but in studying the effects of close work on myopia we must take into account accommodation also, and further the close association between accommodation and convergence. In this connection it is significant that the ciliary muscle in the myopic eye is undeveloped when compared with the emmetropic or hyperopic eye. It may be presumed, therefore, that the ciliary muscle is relatively weak before the onset of myopia. Under these conditions if the child with exophoria holds objects closer to his eyes than is normal, for reasons previously mentioned, both convergence and accommodative efforts are excessive. Alternatively, where the connection between the two functions is extremely rigid an increased convergence effort will induce an increased accommodational effort. Thus where an excessive convergence is required as the result of exophoria, the effect might indirectly produce a spasm of accommodation, a condition almost invariably found in youth, which, bearing in mind the age of onset of myopia is not without significance.

Taking into account a weakened sclera, excessive convergence and accommodation produced through exophoria, it is suggested that low degrees of myopia are produced in eyes originally hyperopic through the turnstile of spasm of accommodation. The constant accommodative convergence effort causes nature to adapt the construction of the eye which is mainly used for close work so that it may operate in comfort. This adaptation is achieved through pressure on a weakened sclera by the external recti, and an elongated globe results.

It may be argued that children are at times refracted under a cycloplegic, which would reveal spasm of accommodation if present. This contention, however, can only be upheld if it can be proved that accom-

modation is fully relaxed under a cycloplegic. Statistics showing that the total refractive error revealed under cycloplegia equals that revealed when the subject has reached middle age are lacking. Moreover, it has been reported that atropine instilled in both eys for a long period brings about a reduction of myopia in some cases. Whether a cycloplegic discloses the total refractive error or not, however, is not of importance because it is seldom that the refractionist is consulted before myopia has developed.

The more we study the cause and progress of myopia the conviction that it should be treated rather than merely corrected by the provision of concave lenses grows stronger. It cannot be accepted that the disease is a physiological condition which develops purely through hereditary influences. Consequently any mode of treatment, whether orthodox or not, that succeeds in some measure in arresting its progress is worthy of investigation. Several authorities have advocated the use of base-in prisms incorporated with the full correction of the refractive error with more or less satisfactory results, the basic idea being to afford relief of the exophoria and convergence effort. If, however, the same result can be achieved by means of exercises then this mode of treatment is to be preferred.

Treatment based on the theory that the excessive convergence effort induces spasm of accommodation, which in turn develops into myopia, or where, in established myopia, the excessive convergence influences the progress of the disease, must have for its aims (a) relief of exophoria; (b) relief of accommodation; (c) the establishment of a fluid connection between accommodation and convergence; (d) maximum relaxation of convergence while under the stimulus of fusion and (e) adequate fusional reserves. The writer has endeavored to meet these requirements with the following procedure.

Naturally, the first step is to consider to what extent the refractive error shall be corrected. In cases below 2.5 D. the distant vision is left uncorrected, but an empirical reading correction of weak convex lenses combined with base-in prisms is prescribed for close work where the defect is below 1.5 D. and one consisting of reduced concave lenses with base-in prisms when between 1.5 D. and 2.5 D. Where the defect exceeds 2.5 D. a reduced correction combined with base-in prisms is given for constant wear and a still more reduced correction for close work. These corrections are adapted accordingly as unaided vision improves under treatment.

Secondly, the patient is provided with a Remy Separator for home exercise, in order that accommodation and convergence shall be fully relaxed. This is achieved by practice of the mental effort exercise in a similar manner to that adopted for treatment of convergent strabismus. Two cards portraying dissimilar objects are placed on each side of the septum as far apart as possible. The patient is instructed to view both objects simultaneously and then transfer his gaze to an imaginary distant and lofty object. By this effort the two objects will appear to approach one another, and become superposed. If the objects are superposed at the commencement of the exercise, the cards must be placed still wider apart.

In addition, orthoptic exercises are given in the consulting room on the prism stereoscope or Synoptophore. These exercises are designed to loosen and render more fluid the association of accommodation and convergence. Lenses are placed in the instrument in order to ensure that the stereograms are viewed with relaxed accommodation, and the negative fusional reserves exercised. This treatment is perhaps unorthodox in exophoria, and it might be suggested that adduction exercises may increase the exophoria, but in the writer's experience exophoria has not increased in any one case. Patients are instructed to avoid close work as much as possible and to be particular to use the correction provided when close work is unavoidable.

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AN OPHTHALMOLOGIST INDICATES THAT THE FIELD OF REFRACTION BELONGS TO OPTOMETRY

In 1901 the first Optometry Law was passed in Minnesota. There was little organized opposition to the passage of that Law. Since that time all other States in the Union succeeded in passing optometry laws, but nearly all other States had to fight some organized opposition on the part of the medical profession. The reasons given why optometry should not be legalized as a profession were many. The two outstanding "stock and trade" arguments were:

(1) That optometrists did not care to use cycloplegics and that in the judgment of the opponents no accurate refraction could be performed without a cycloplegic. Time has dealt rather harshly with this argument. The experience of the public has proven its fallacy as indicated by the fact that a great majority of the people wish to have their eyes examined without a cycloplegic and find they can successfully have this done. They find also that their glasses are more comfortable when prescribed without the use of drugs. The final blow was delivered to this argument by the

researches carried out by Tait and Sinn, which showed that refractive results are less accurate when a cycloplegic is used. As a matter of fact a large number of ophthalmologists have discontinued the use of a cycloplegic in their refraction and that number we believe is constantly increasing.

(2) The second argument used against optometry was that many eye symptoms are due to constitutional diseases. The Optometrist being trained but little in general pathology, was likely to prescribe glasses and overlook these constitutional disorders. From experience we now know that cases of this type are not very numerous, and when such cases are found by optometrists they are referred to the physician for treatment. This argument did not carry much weight with the legislators, as is now well known, with the result that the legislatures of the forty-eight states passed laws legalizing the practice of Optometry as a separate profession from medicine.

Of late, since many relief agencies have set up special facilities to provide refracting eye service to the needy, (this work is being usually carried out by an administrative committee) numerous ophthalmological groups have persuaded many of these commissions or committees to send all persons who need optometric service to the ophthalmologists. The ophthalmologists, in order to carry their point, have revived the old argument, namely "that optometrists not being physicians may by chance prescribe glasses to patients whose ocular symptoms are due to constitutional diseases." Unfortunately this argument has succeeded in several instances.

It is up to optometry once and for all to disprove this argument. Not because their own welfare is involved, but because the public welfare is involved. To accomplish this we shall turn to ophthalmology for facts and figures to disprove this statement.

Harman N. Bishop (in the British Medical Journal, Supplement, February 4, 1939) gives a summary of the statistical analysis of 50,000 unselected cases refracted during the last five years. The results are given in the following table:

Table I

	Number of cases	Percentage of total
Total cases analyzed	50,741	100.00
Errors of refraction	32,295	63.65

Errors of refraction and other eye conditions	14,047	27.68
Other eye conditions only	4,008	7.90
No appreciable defect	391	0.77

Table II

ERRORS OF REFRACTION		
Hypermetropia	7,069	13.93
Hypermetropia and/or astigmatism	21,132	41.65
Myopia	2,206	4.35
Myopia and/or astigmatism	9,666	19.05
Mixed astigmatism	1,899	3.74
Odd eyes	2,478	4.88
Presbyopia	19,962	39.34
OTHER EYE CONDITIONS		
Conjunctiva	3,717	7.33
Cornea	1,140	2.25
Uvea	2,039	4.02
Optic neuritis or atrophy	485	0.96
Cataract	3,771	7.43
Glaucoma	381	0.75
Myopia over 5D	1,616	3.18
Squint	3,726	6.46
Constitutional diseases, etc.	2,273	4.48
Bad conditions of work	238	0.47
Injuries, or effects of	503	0.99
Other material conditions	1,833	3.61

A study of the figures in Table II are indeed interesting. Under the second part of this table entitled, Other Eye Conditions, we find listed, Conjunctiva, Cornea, Uvea, Optic atrophy, Cataract, Gloucoma, Myopia, over 5.00 D, and Squint.

No one who is acquainted with subjects taught in the Optometry Colleges (all of them teaching four year courses) will honestly claim that optometrists are not capable to detect these conditions when present. Of these cases only Cornea, Uvea, Optic Atrophy, Glaucoma, (5.88 per cent) need medical attention. That does not mean that medical treatment will help in all these cases. We as optometrists who refer these cases to ophthalmologists know only too well how few of these

cases of Glaucoma, Corneal scars or Optic Atrophy are helped by the use of medication, or surgery.

Next in the table we come to "constitutional disease." These cases amount to 4.48 per cent. From actual clinical experience we know that the modern optometrist does recognize many of the ocular cases which are due to constitutional diseases. The number of patients optometrists refer to the general medical or dental practitioner for an examination is sufficient proof of this statement. However, even if we should assume that the entire group of constitutional disease cases are overlooked by the optometrist it would simply mean that the optometrist would be off on his diagnosis 4.48 per cent., i. e. optometrists diagnosis would still be correct in 95.52 per cent. If for the sake of argument we should claim that the optometrists would not only overlook effects of all constitutional disease but also overlook all of the Optic Atrophy, Cornea, Uvea and Glaucoma cases, in that event incorrect diagnosis of optometrists would still amount to but 10.36 per cent.

No educator would admit of such possibility, because optometry students in their four year courses are given an extensive training in diagnosis particularly in ocular pathology.

Bishop, by supplying the statistics mentioned in these pages rendered a great service to Ophthalmology, Optometry and the Public. The fact brought out by Bishop in his figures are that ocular symptoms due to constitutional diseases amount to the negligable total of but 4.48 per cent. This is indisputable proof of optometry's contention—namely that the field of refraction belongs to Optometry.

JACK I. KURTZ

* * * * *

ABSTRACTS

A QUANTITATIVE STUDY OF THE VISUAL-AFTER-IMAGE, William Feinbloom, Ph.D., Archives of Psychology, November, 1938.

Feinbloom made an extensive experimental study of the visual-after-image.

In this experiment he aimed to determine:

1. The relation of the latent period and duration of the visual-after-image.
   (a) Time in the dark.
   (b) To Time of Exposure of the Stimulus.
   (c) To Intensity of the Stimulus.
   (d) To the Color of the Stimulus.

Numerous tests were made. These showed that both the Latent Period and Duration of an after-image-increases with an increase in Time in the Dark; that for constant state of dark adaptation there is an increase in both the Latent Period and Duration with an increase in external Stimulus; that a change in the external stimulus of either Intensity or Time of exposure will cause a corresponding change in the latent Period and Duration of Visual after-image; that after images are heterochromatic and not monochromatic, and that their color composition changed with the change of intensity of the stimulus. The dominant color of the stimulus is carried over to the after-image even when the after-image lasts for ten to fifteen seconds.

This study adds much to our knowledge about after-images. As the fund of this knowledge is increased the optometrist will be in a position to turn it to practical clinical application for the study of binocular vision and the condition of cellular activity of the retina.

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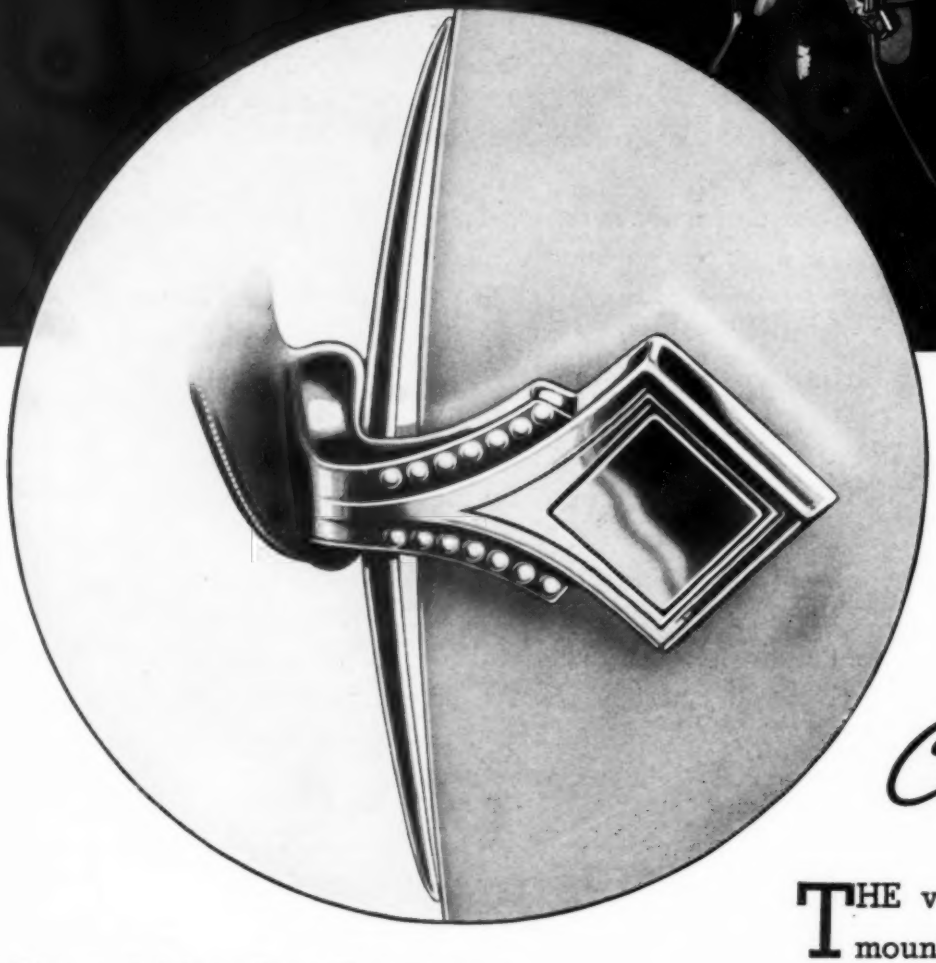

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